Introduction to Observing System Simulation Experiments (OSSEs)

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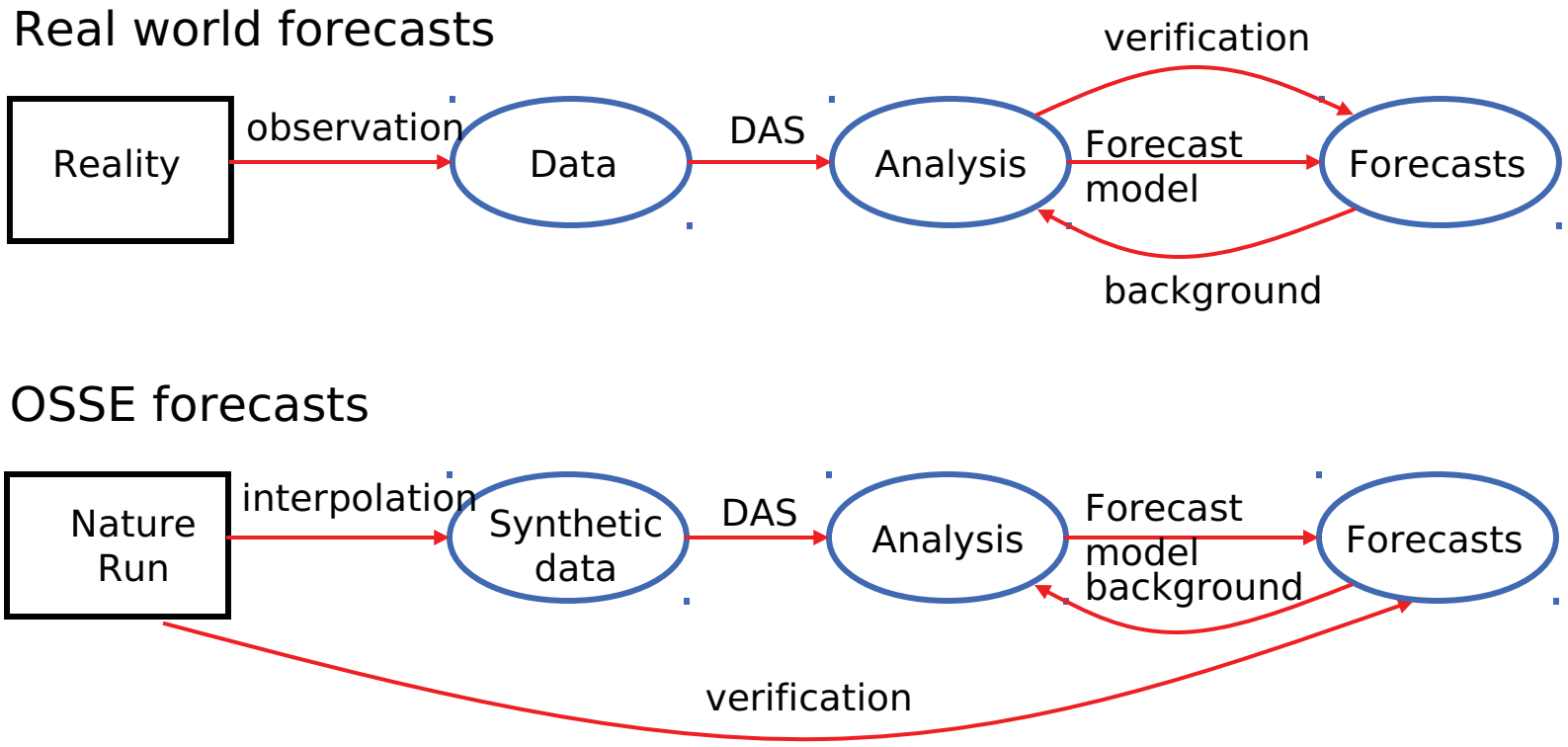
What is an OSSE?

An OSSE is a modeling experiment used to evaluate the impact of new observing systems on operational forecasts when actual observational data is not available.

- A long free model run is used as the "truth" - the Nature Run
- The Nature Run fields are used to back out "synthetic observations" from all current and new observing systems.
- The synthetic observations are assimilated into a different operational model
- Forecasts are made with the second model and compared with the Nature Run to quantify improvements due to the new observing system

OSSEs vs. the Real World



Nature Run Requirements

- Nature Run will act as the ‘truth’
  - Advantage: we know everything
- Must be able to realistically model phenomena of interest
  - Dynamics and physics should be realistic
  - Must produce fields needed for “observations”
  - Should be verified against real world
- Usually a ‘free’ run of a numerical weather model
- Ideally is ‘better’ than operational forecast model

Synthetic Observations

- Want to replicate **all** observational types used operationally
- Also need to make observations for new data types
- Interpolation from Nature Run fields to mimic spatial and temporal distribution of real observations
- Add errors to make observations less perfect

Forecast Model Requirements

- Data Assimilation System must be able to ingest both current and new data types
- Forecast model ideally similar to an operational model
- Forecast model should be distinctly different from the model used to make the Nature Run
  - ‘identical twin’ cases use the same model
  - ‘fraternal twin’ cases use similar models

Experiments

- Experiments are conducted similarly to OSEs, but with new data added instead of removed
- Choice of metric is important for designing experiments and interpreting results
- May need to run multi-month tests to see statistically significant results

Regional OSSE

- Much harder, more effort than global OSSE
- Need two Nature Runs – regional Nature Run embedded in global Nature Run
- Need to embed a second regional forecast model in a global OSSE to perform experiments
- Boundary conditions complicate all aspects
- Very rarely performed in full – major shortcuts are common

But can you trust it?

- Because every aspect of the OSSE is modeled, verification and calibration of the entire system is needed
- Run forecast model with real data and then again with OSSE system, compare results
  - Forecast skills
  - Observation impacts (OSE, adjoints)
  - DAS statistics (analysis increments, O-F, etc)

When to do an OSSE

- New observations are likely to be ingested into operational forecast models
- Real observations are unavailable or prohibitively difficult/expensive
- Questions about instrument design and/or deployment

When NOT to do an OSSE

- Real data is already available – do an OSE
- Models cannot replicate phenomena of interest
- Data assimilation cannot ingest the new observations

Pitfalls and Caveats

- OSSEs are not inexpensive
- Long lead times between OSSE and implementation – lots of changes to the model skill and observational network
- Beware of shortcuts
  - Omission of competing obs types from OSSE
  - Twin experiments